EJFA Emirates Journal of Food and Agriculture

Emirates Journal of Food and Agriculture 37: 1–9
doi: 10.3897/ejfa.2025.149360

RESEARCH PAPER

Antioxidant and antibacterial activity of two dairy camel milk products: yoghurt and cheese

Imen Fguiri[1], Amel Sboui[1], Samira Arroum[1], Mohamed Dbara[1], Mohamed Hammadi[1], Touhami Khorchani[1]

1 *Livestock and Wild Life Laboratory, Institute of Arid Regions (IRA), 4119 Medenine, Tunisia*

Corresponding author: Imen Fguiri (imen.fguiri@yahoo.com)

Academic editor: Khaja Mohteshamuddin ♦ **Received** 18 February 2025 ♦ **Accepted** 2 October 2025 ♦ **Published** 3 November 2025

Abstract

This work focused on producing yoghurt and cheese from camel milk and assessing their physicochemical features along with biological activities. Converting camel milk into fermented products such as yoghurt and cheese is a common preservation approach; however, it remains challenging due to the difficulty of achieving proper coagulation. In this study, camel milk cheese was prepared using enzymatic extracts derived from kiwi and artichoke and compared with cheese obtained with commercial chymosin. The analyses revealed that the cheeses differed in their physicochemical profiles: kiwi extract produced a more acidic product with a higher protein concentration (40.25 g/L) than that obtained with artichoke extract (32.43 g/L). Cheese yield was also greater with the plant enzymes (22.66% for kiwi and 21.06% for artichoke) compared with chymosin (15.55%). Camel milk yoghurt displayed notable physicochemical properties, including elevated protein levels (23.44 g/L), high viscosity (300 cP), and considerable lactose, acidity, and ash content. The antioxidant capacity was assessed using DPPH radical scavenging, ferric reducing power, and hydrogen peroxide scavenging assays. Results showed a dose-dependent increase in antioxidant activity, with camel yoghurt and cheese exhibiting maximum values of 61.58% and 14.9%, respectively, when compared with ascorbic acid. Antibacterial potential was determined using the agar diffusion method against seven pathogenic bacteria. Both camel milk yoghurt and cheese demonstrated significant inhibitory effects on all tested strains.

Keywords

Camel milk, Cheese, yogurt, antioxidant activity, antibacterial activity

Introduction

Camel milk presents unique compositional features that make it an attractive substitute for bovine milk. In comparison with milk from other ruminants, it is appreciated for its easy digestibility in the human gut, a property linked to its smaller fat globules and low allergenic potential. Importantly, camel milk does not contain β-lactoglobulin—one of the main allergens present in cow's milk—thus representing a safer alternative for individuals with dairy sensitivities (Lajnaf et al. 2022).

The whey proteins, caseins, and lactic acid bacteria (LAB) present in camel milk have been widely investigated for their health-promoting roles, including antioxidant, probiotic, antimicrobial, anti-inflammatory, and immunomodulatory effects (Alhaj et al. 2022). Moreover, recent findings indicate that fermentation and gastrointestinal digestion of camel milk proteins can generate bioactive peptides with strong radical-scavenging capacity and immune-enhancing functions (Zhang et al. 2023). Camel milk continues to serve as a key dietary component for nomadic communities, where it is consumed in both raw and fermented forms. Although yogurt and cheese production originally aimed to extend the shelf life of milk, the use of diverse microbial starters has since expanded the range of fermented camel milk products, offering varied textures, flavors, and functional health benefits (Rahman et al. 2024).

Copyright *Fguiri, et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Camel milk is characterized by its limited coagulation ability, which poses challenges for producing conventional dairy products such as cheese, yoghurt, and butter. The slow progress in developing and standardizing camel milk–based dairy products is largely linked to its distinctive structural and functional properties (Seifu 2023). For instance, the relatively low level of κ-casein weakens the casein micelle structure, causing it to disintegrate during curd cutting, which in turn promotes excessive whey loss and reduces cheese yield (Seifu 2023). Recent advances have demonstrated better results in camel milk yogurt production through the incorporation of stabilizers such as gelatin, alginate, and calcium, which contribute to improved sensory attributes and texture (Ayyash et al. 2023). Similarly, cheesemaking from camel milk has become more practical with the introduction of alternative coagulants, including camel chymosin and enzymes of plant origin (Ait et al. 2023). Plant-based rennets, particularly extracts from kiwi (*Actinidia deliciosa*) and artichoke (*Cynara scolymus*), have been identified as promising substitutes for conventional animal chymosin in cheese manufacture. Kiwifruit contains actinidin, a cysteine protease known for its strong milk-clotting ability and a favorable ratio of milk-clotting to proteolytic activity, similar to that of calf rennet. This enzyme shows peak performance under standard cheesemaking conditions, namely at pH 5.5 and 40 °C (Nicosia et al. 2022). Moreover, cheeses produced using kiwi extract have been reported to possess enriched nutraceutical qualities, with increased polyphenol and phytosterol contents, while maintaining acceptable flavor characteristics (Serra 2020). Likewise, artichoke extracts have shown notable potential as milk-clotting agents, mainly due to their content of aspartic proteases concentrated in mature flower heads. These enzymes act selectively on casein micelles, making them effective candidates for dairy coagulation (Bolivar et al. 2023). Cheeses produced with artichoke-derived coagulants have also been reported to display favorable texture and sensory properties, comparable to those obtained with conventional rennet (Pacifico et al. 2024). By comparison, the use of chymosin, a traditional animal-derived coagulant, often results in cheeses with higher water retention and a more elastic consistency, characteristics that may not always suit certain cheese types.

Ongoing studies remain crucial to improving the technological performance, quality, and yield of dairy products based on camel milk. Advancements in camel milk yogurt and cheese production could not only broaden the range of dairy products available on the market but also provide greater economic opportunities and enhance the livelihoods of camel herding communities.

Material and methods

Sampling

Camel milk was obtained from dromedary camels (Camelus dromedarius) reared in the experimental herd of the Arid Regions Institute (IRA, Medenine, Tunisia). The samples were transported to the laboratory in insulated containers and immediately subjected to analysis and processing.

The enzymatic extracts of kiwi (*Actinidia deliciosa*) and artichoke (*Cynara scolymus*) are already prepared as mentioned in Fguiri et al. 2021 and stored in the laboratory at -20 °C.

Yoghurt manufacture

Fresh raw camel milk was first preheated to 65 °C and then homogenized. Pasteurization was carried out at 65 °C for 30 min, after which the milk was cooled to 42 °C. To reach a dry matter content of 14%, skim milk powder was added. The prepared milk was subsequently inoculated with a starter culture containing *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*.

Cheese making process

Camel milk was subjected to pasteurization at 65 °C for 30 min and subsequently cooled to 40 °C. After approximately one hour, enzymatic extracts derived from kiwi and artichoke were incorporated at a level of 10% (v/v) and thoroughly mixed. The inoculated milk was then incubated at 37 °C for 24 h. Following coagulation, the whey was removed, and the resulting fresh cheese was stored at 4 °C until further analysis.

Yoghurt and cheese characterization

Physicochemical analyses were carried out following international standard procedures (AFNOR 1993). Total protein content was quantified using the classical Kjeldahl method (1883).

Antioxidant properties

DPPH radical scavenging activity

The ability to scavenge 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals was assessed following the method of Bersuder et al. (1998), with minor modifications. Briefly, yoghurt and cheese extracts (1–7 mg/mL) were mixed with a DPPH ethanolic solution (125 µM) and kept in the dark for 1 h at room temperature. Absorbance was then recorded at 517 nm using a UV-Vis spectrophotometer (Cecil CE 2041; Cecil Instruments Ltd). Results were expressed as scavenging percentage using the formula:

$$\text{DPPH scavenging activity (\%)} = [(Ac - As) / Ac] \times 100$$

where Ac is the absorbance of the control and As that of the sample.

Ferric reducing antioxidant power (FRAP)

The reducing activity was determined according to Wu et al. (2003), with modifications. Samples (1–20 mg/mL) were reacted with phosphate buffer (0.2 M, pH 6.6) and potassium ferricyanide (1%, w/v), incubated at 50 °C for 20 min, and treated with trichloroacetic acid (10%, w/v). After centrifugation (3000 × g, 10 min), the supernatant was mixed with distilled water and ferric chloride (0.1%, w/v). Absorbance was measured at 700 nm after 10 min.

Hydrogen peroxide scavenging assay

Hydrogen peroxide scavenging activity was evaluated as described in previous studies, using ascorbic acid (1 g/L) as a positive control. Samples (yoghurt, milk, and cheese) were mixed with H_2O_2 solution (40 mM), and absorbance was recorded at 230 nm at the start and after 60 min of incubation.

Antibacterial activity

Antibacterial activity was evaluated using the agar well diffusion method. The test organisms included *Escherichia coli*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella typhi*, *Listeria innocua*, *Pseudomonas aeruginosa*, and *Enterococcus faecalis*, all obtained from the laboratory culture collection. Pathogenic strains were first cultured in Brain Heart Infusion (BHI) broth and incubated for 24 h at 37 °C. Antibacterial activity was then assessed according to the procedure of Barefoot et al. (1983), with modifications. Briefly, yoghurt and cheese samples were placed in 4.5 mm wells prepared aseptically in Mueller–Hinton agar previously inoculated with the target strain. Each well was filled with 80 µL of sample, and plates were kept at 4 °C for 4 h to allow proper diffusion of antimicrobial compounds (Doumadji et al. 2010). Incubation was then carried out at 37 °C, and inhibition zones were evaluated after 24–48 h (Hwanhlem et al. 2011).

The diameter of the inhibition zones (Zi, mm) was measured, and inhibition was considered positive when Zi exceeded 2 mm (Thompson et al. 1996).

Zi (mm) = inhibition zone diameter (mm) – Wells diameter (4.5 mm)

Statistical analysis

All data were analyzed by analysis of variance (ANOVA) using the GLM procedure in SAS software (version 9.0). Results are presented as mean ± standard deviation, and mean comparisons were performed using Duncan's multiple range test at a significance level of $p \leq 0.05$ (Cochran and Cox 1992). Each measurement was conducted in triplicate.

Result and discussion

Physicochemical characteristics of camel yoghurt

The physical characteristics of yoghurt are crucial in determining its overall quality. Table 1 presents the physicochemical properties of camel milk yoghurt. Its acidity largely contributes to the characteristic sour and refreshing taste. In the current study, the average titratable acidity of camel milk yoghurt was 1.18%, which is higher than the 0.78% reported by Bhagiel et al. (2015). Al-Zoreky and Al-Otaibi (2015) recorded a pH range of 4.59–4.63 and titratable acidity of 0.71–0.87% lactic acid for camel milk yoghurt produced in Saudi Arabia. Hashim et al. (2009) reported pH values between 4.3 and 4.5 and titratable acidity ranging from 0.98 to 1.16% for yoghurt prepared with added gelatin, alginates, and calcium chloride. The pH in this study was 4.28, indicating a relatively higher acidity.

Table 1. The physicochemical characteristics of camel yoghurt.

	Camel yoghurt	P-value
pH	4.28 ± 0.02	<0.0001
Acidity (°D)	118.33 ± 10.11	0.54
Viscosity (cP)	300 ± 31.6	<0.0001
Dry Matter (g/l)	124.66 ± 3	0.0002
Ash (g/l)	8.44 ± 1.08	<0.0001
Fat (%)	36.16 ± 4.67	<0.0001
Proteins (%)	23.44 ± 2.26	0.005
Lactose (g/l)	13.59 ± 0.99	0.001

The difference is statistically significant if $p < 0.01$.

The total solids (TS) content measured in the present study was 12.24%, exceeding the values reported by Bhagiel et al. (2015) and Bashir (2009), which were 11.83% and 11.3%, respectively. TS content in yoghurt is influenced by the TS of the raw milk, which varies seasonally; it tends to decrease during hot seasons due to higher water content in camel milk to support calf nourishment (Bhagiel et al. 2015).

The ash content in the yoghurt analyzed here was higher than the 0.71% reported by Eissa et al. (2011) for camel milk yoghurt produced in Sudan. Ash content reflects mineral levels, which are essential for bone and teeth development and various physiological functions (Bibiana and Joseph 2014). The protein content of the yoghurt was 23.44%, while lactose concentration was 13.59 g/L.

Physicochemical characteristics of camel milk cheese

The physicochemical properties of camel milk cheese are summarized in Table 2. Significant differences ($P < 0.05$) were observed among cheese samples prepared using kiwi and artichoke crude extracts (KCE, ACE) and commercial camel chymosin (CC).

In this study, cheese produced from camel milk showed lower pH values compared to those reported in the literature. For example, Fguiri et al. (2021) reported a pH of 6.01 for camel milk cheese prepared with kiwi extract, while Inayat et al. (2003) recorded a similar pH of 5.23 for cheese made with CC, comparable to the values obtained here. The higher titratable acidity observed for KCE- and ACE-coagulated cheese may be attributed to the type of coagulant, the processing temperature, and the duration of cheese-making, all of which can influence the acidification process.

Total solids were higher in cheese prepared with KCE compared to those made with ACE and CC (Table 2). Previous studies have reported higher total solids in camel milk cheese, e.g., 44.4% and 45.5% by Khan et al. (2004) and Mehaia (1993), respectively. Such variations can be influenced by multiple factors, including the composition of ingredients and the ash content of the raw milk. Mehaia (2006), for instance, reported that the addition of salt during cheese production increased the ash content of Domiati cheese.

Protein content and cheese yield were also greater in samples prepared with KCE and ACE than with CC (Table 2). Differences in protein levels among cheese types may result from the hydrolytic activity of the coagulants used (Bekele 2014). In this study, cheese yields were 22.66% with kiwi extract (*Actinidia deliciosa*) and 21.06% with artichoke extract (*Cynara scolymus*), both significantly higher than the yield obtained with commercial chymosin (15.55%). These results indicate that plant-derived proteases can serve as effective alternatives to animal rennet, offering comparable or even superior coagulation efficiency under specific conditions.

Table 2. physicochemical characteristics of camel milk cheese.

	CC	KCE	ACE	P-Value
pH	5.57 ± 0.39	4.44 ± 0.04	4.42 ± 0.01	<0.0001
Acidity (°D)	83.3 ± 5.7	156.56 ± 20.8	193.33 ± 5.7	0.0002
Dry Matter (g/l)	28.5 ± 2.45	31.5 ± 0.38	25.4 ± 1.1	<0.0001
Ash (g/l)	0.29 ± 0.04	0.15 ± 0.01	0.16 ± 0.01	0.0019
Fat (%)	16.5 ± 2.1	9.5 ± 0.5	16.5 ± 0.71	0.001
Proteins (%)	17.67 ± 1.5	40.25 ± 0.005	32.43 ± 1.5	0.0005
Lactose (g/l)	9.6 ± 1.2	10.44 ± 0.8	8.7 ± 0.3	0.01
Yield (%)	15.55	22.66	21.07	0.01

CC: Camel Chymosin; KCE: Kiwi Curde Extract, ACE: Artichoke Curde Extract ; The difference is statistically significant if $p < 0.01$.

Recent research supports these findings, emphasizing the interest in plant-based milk-clotting enzymes for ethical, dietary, and economic reasons. For instance, García-Gómez et al. (2020) demonstrated that actinidin in kiwi extract is a cysteine protease capable of efficient milk coagulation while imparting unique sensory properties to the cheese. Similarly, Feiden et al. (2023) showed that artichoke flower extracts, rich in aspartic proteases such as cynarase, provide high clotting activity and yield without adversely affecting texture.

However, it is important to consider that the use of plant-based coagulants can influence flavor, texture, and ripening profiles differently compared to animal rennet, which warrants further standardization and optimization in industrial cheese-making applications (Kilic and Koyuncu 2024).

Antioxidant activity of camel yoghurt

In this study, the antioxidant properties of camel milk yoghurt were assessed using DPPH radical scavenging, ferric reducing antioxidant power (FRAP), and hydrogen peroxide (H_2O_2) scavenging assays.

Phenolic compounds are considered the primary contributors to antioxidant activity (Sroska and Cisowski 2003). In addition, the proteolysis of milk proteins (Lourens-Hattingh and Viljoen 2001) and the production of organic acids (Correia et al. 2005), resulting from microbial metabolism during fermentation and refrigerated storage, may also contribute to the observed antioxidant effects.

Fig. 1 A reports the DPPH radical-scavenging capacity of camel yoghurt in comparison with ascorbic acid. Camel yoghurt possessed great DPPH scavenging capacity (86.57%), this result is in agreement with those of Virtanen et al. (2007) who reported that antioxidant activity increased during fermentation in some cases. Several studies have shown that fermented camel milk can release peptides having various biological activities. The release of peptides with antioxidant activity during fermentation of camel milk has been demonstrated by several researchers. (Moslehishad et al. (2013); Balakrishnan and Agrawal (2014); Soleymanzadeh et al. (2016); Ayyash et al. (2018)).

Fig. 1B shows the results of H_2O_2 trapping test of camel yoghurt in comparison with ascorbic acid. Camel yoghurt possessed high antioxidant activity (33.87%).

Fig. 1C shows the ferric reducing antioxidant power (FRAP) of camel milk yoghurt at different concentrations. The FRAP values of all samples increased with concentration, indicating a dose-dependent effect. At 2.5 mg/mL, camel milk yoghurt exhibited higher antioxidant activity than the standard. These findings are consistent with those of Ayyash et al. (2017), who reported that fermented camel milk demonstrated greater antioxidant activity compared to bovine milk.

Antioxidant activity of camel cheese

Fig. 2 shows antioxidant activity of camel milk cheese manufactured with kiwi and artichoke extract compared with chymosin and standard (acid ascorbic).

Camel milk cheese with artichoke extract showed higher antioxidant activity than that with kiwi and chymosin based on FRAP, H_2O_2 trapping test and DPPH assays.

Fig. 2 showed significantly that the DPPH radical scavenging activity of camel cheese with artichoke was very high (75.82%) and close to ascorbic acid activity 88.15%. The antioxidant activity of camel cheese with kiwi was

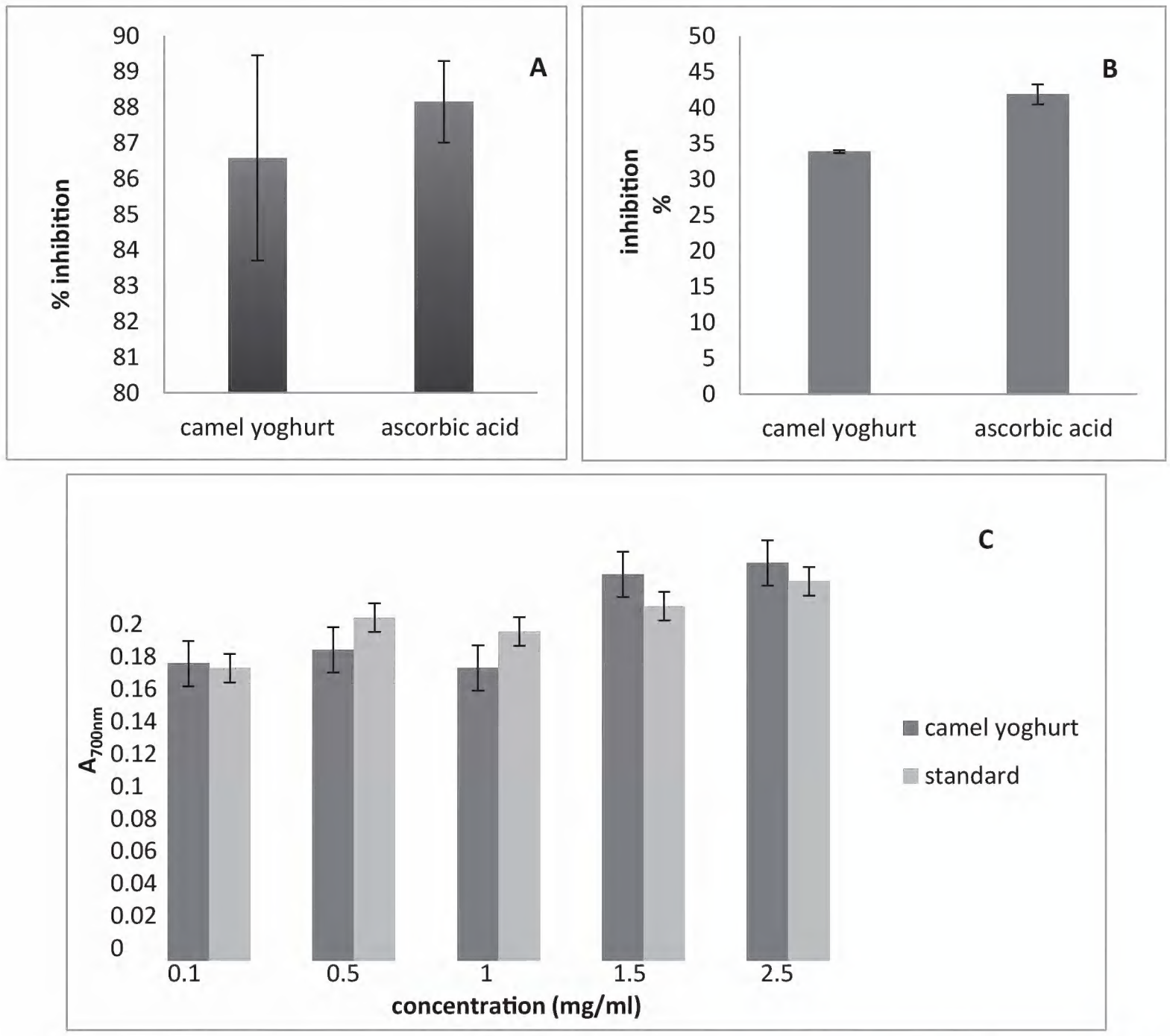

Figure 1. Antioxidant activities of camel yoghurt: **A.** DPPH radical-scavenging activity; **B.** H_2O_2 trapping test; **C.** FRAP ferric reducing power assay.

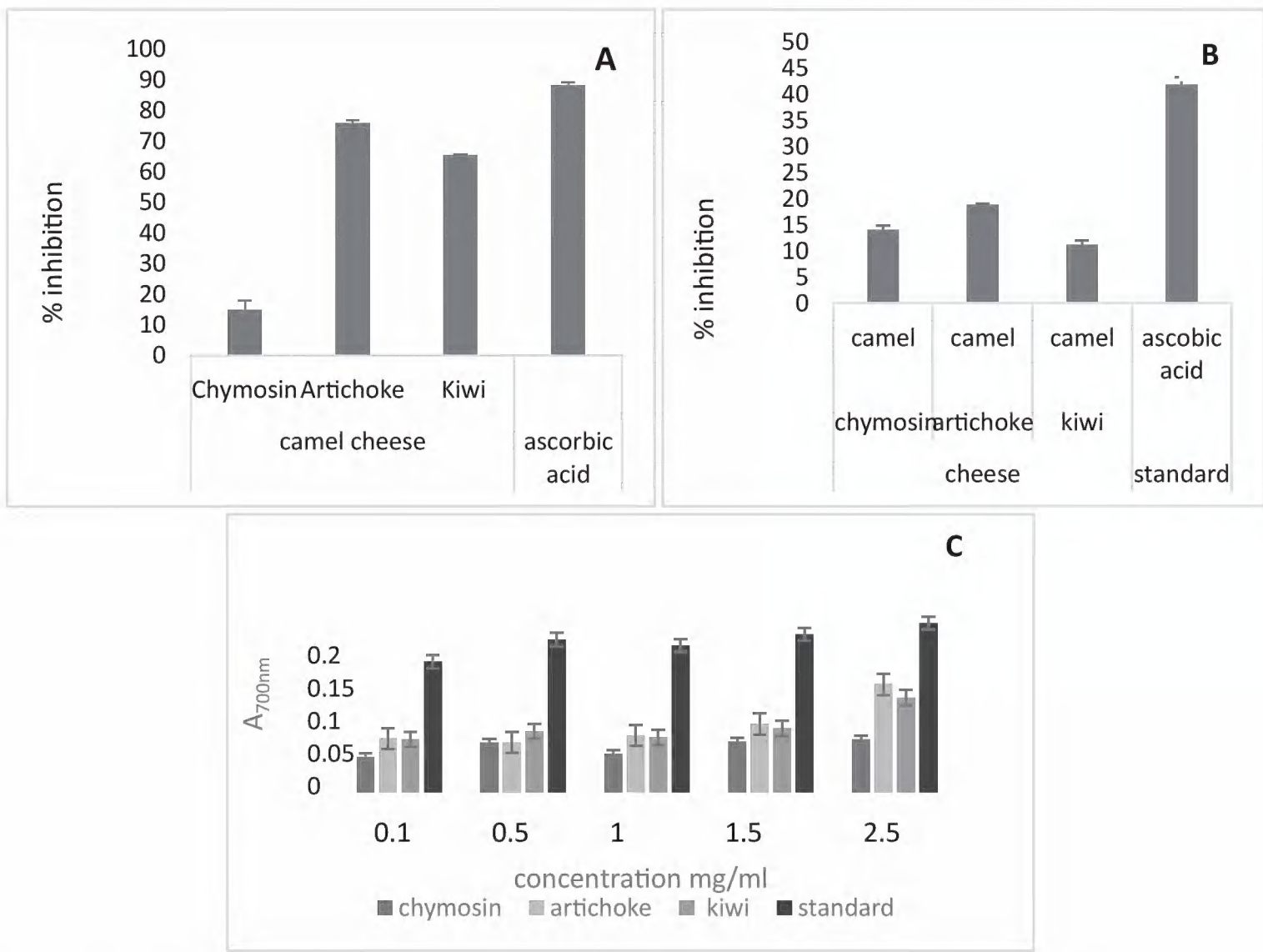

Figure 2. Antioxidant activities of camel Cheese: **A.** DPPH radical-scavenging activity; **B.** H_2O_2 trapping test; **C.** FRAP ferric reducing power assay.

65.4%. This may be due to camel milk proteins which have the ability to neutralize DPPH radicals (Brandelli et al. 2015; Saadi et al. 2015).The antioxidant activity of camel milk can also be attributed to its high ascorbic acid content (Stahl et al. 2006). Moreover Gil-Izquierdo (2001) and Fratianni (2007) reported that artichoke leaves are used in traditional medicine for their healing virtues and their antioxidant and antimicrobial properties. These biological activities are essentially attributed to caffeoylquinic acids and their derivatives (chlorogenic acid and cynarin) and to flavonoids (luteolin 7-O-glucoside).

Antibacterial activity of camel yoghurt

The antibacterial activity of camel milk yoghurt samples is shown in Fig. 3. All tested samples exhibited notable inhibitory effects against the pathogenic strains, with the strongest activity observed against *Enterococcus faecalis* (23 mm) and the weakest against *Pseudomonas aeruginosa* (8 mm).

Previous studies have investigated the effects of various fermented products, including yoghurt and kefir, on a broad spectrum of Gram-positive and Gram-negative bacteria. These investigations demonstrated that microorganisms present in fermented foods can inhibit the growth of *Staphylococcus aureus*, *Shigella* spp., *Salmonella* spp., *Escherichia coli*, *Listeria monocytogenes*, *Bacillus cereus*, *Bacillus subtilis*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Enterococcus faecalis* (Namaei et al. 2015; Kim et al. 2016). The antimicrobial effects are likely due to bioactive compounds such as organic acids, ethanol, hydrogen peroxide, diacetyl, peptides, and possibly bacteriocins, among other inhibitory substances.

Antibacterial activity of camel cheese

Fig. 4 shows the antibacterial activity of camel milk cheese against some pathogenic bacteria.

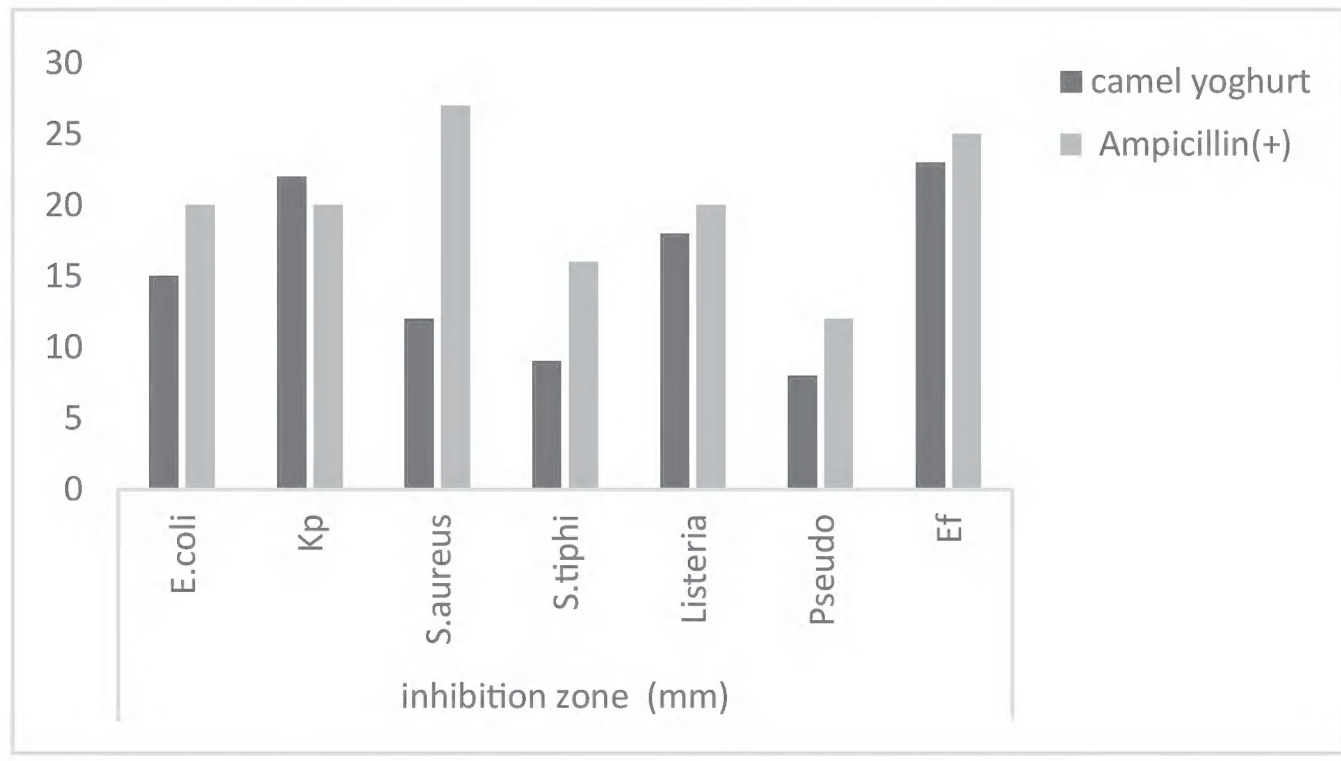

Figure 3. Antibacterial activity of camel yoghurt against 7 pathogenic strains (*E. coli*; *Klebsiella pneumonia*: Kp; *S. aureus*; *Salmonella tiphi*; *Listeria inocua*; *Pseudomonas aeruginosa*; *Enterococcus feacalis*).

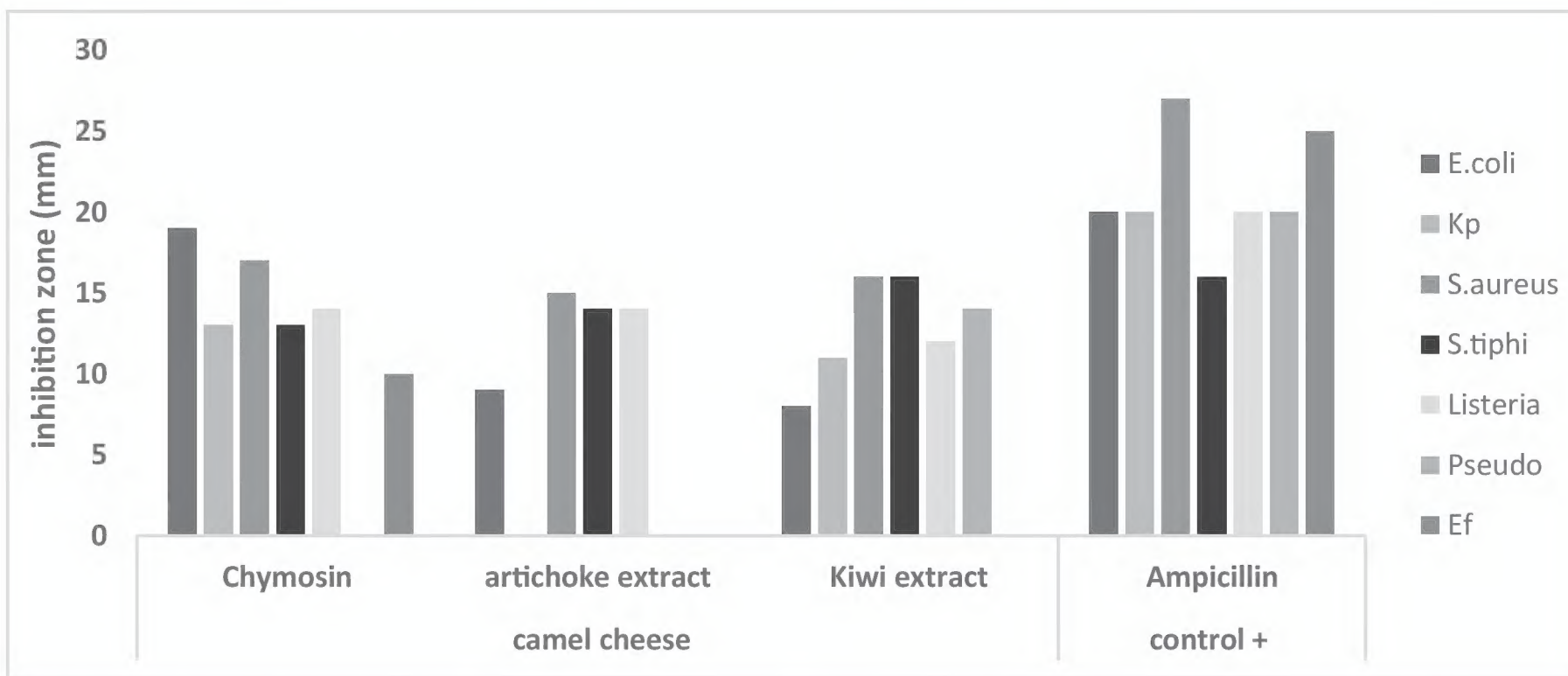

Figure 4. Antibacterial activity of camel cheese against 7 pathogenic strains (*E. coli*; *Klebsiella pneumonia*: Kp; *S. aureus*; *Salmonella tiphi*; *Listeria inocua*; *Pseudomonas aeruginosa*; *Enterococcus feacalis*).

According to Fig. 4, the majority of the samples show an inhibitory activity, more or less pronounced, on all the pathogenic bacteria.

These results indicate that our samples contain inhibitory substances with antibacterial activity. All the samples do not present the same spectrum of action against pathogenic bacteria.

The different types of camel cheese exhibit broad-spectrum inhibition against most pathogenic bacteria. The greatest activity was showed in camel cheese with chymosin against *Escherchia coli* (19 mm) and with kiwi extract against *Staphylococcus aureus* (16 mm). The lowest activity was observed with artichoke and kiwi extract against *Escherchia coli* (9 mm and 8 mm respectively). This activity is due to the presence of a protective system in camel milk, represented mainly by fairly high levels of antimicrobial factors such as lactoferrin, lysozyme, immunoglobulins and lactoperoxidase (Agrawal et al. 2004).

Conclusion

Based on the current body of evidence reviewed, camel milk-derived dairy products such as yoghurt and cheese demonstrate significant antimicrobial and antioxidant activities. These health-promoting effects are largely attributed to the presence of bioactive casein fractions, whey proteins (including lactoferrin and immunoglobulins), and probiotic lactic acid bacteria (LAB) naturally occurring or introduced during fermentation.

Despite these promising findings, most available studies remain in vitro or animal-based, and there is a clear need for comprehensive clinical trials to validate these functional claims in humans. Additionally, standardization of processing techniques—especially for fermented products like yoghurt and cheese—is essential to preserve and enhance these biofunctional properties while ensuring product safety, quality, and consumer acceptance.

Therefore, camel milk and its fermented products represent a valuable area for future research, particularly in the context of functional foods, nutraceuticals, and dietary strategies for health promotion and disease prevention.

Data availability

The data that supported the findings of this study are available from the corresponding authors upon reason-able request.

Conflict of interest

The authors stated that they had no conflict of interest to declare.

Acknowledgements

This study was supported by PAQ-Collabora project financed by Ministry of Higher Education and Research.

References

Abderrahmane NM (1997) Camel milk and modern industry. Journal of Camel Practice Research 4: 223–228.

AFNOR (1993) Contrôle de la qualité des produits alimentaires: lait et produits laitiers: analyses physicochimiques. Paris La Défense: AFNOR, 4e éd., 581 pp.

Agrawal RP, Swamir SC, Beniwal R, kochar DK, Sahani MS, Tuteja FC, Gouri SK (2003) Effect of raw camel milk on glycemic control risk factors and diabetes quality of life on type 1 diabetes: a randomized prospective controlled study. Journal of Camel Practice Research 10(1): 45–50.

Ait El Alia O, Zine-Eddine Y, Ajbli N, Kzaiber F, Oussama A, Boutoial K (2023) Optimization of camel milk coagulation: the use of coagulants of microbiological and plant origin. Acta Scientiarum Polonorum Technologia Alimentaria 22(1): 81–91. https://doi.org/10.17306/J.AFS.2023.1106

Alhaj OA, Lajnaf R, Jrad Z, Alshuniaber MA, Jahrami HA, Serag El-Din MF (2022) Comparison of ethanol stability and chemical composition of camel milk from five samples. Animals 12: 615. https://doi.org/10.3390/ani12050615

Al-Zoreky NS, Al-Otaibi MM (2015) Suitability of camel milk for making yogurt. Food Science and Biotechnology 24(2): 601–606. https://doi.org/10.1007/s10068-015-0078-z

Ayyash M, Abushelaibi A, Al-Mahadin S, Enan M, El-Tarabily K, Shah N (2018) *In-vitro* investigation into probiotic characterisation of *Streptococcus* and *Enterococcus* isolated from camel milk. LWT 87: 478–487. https://doi.org/10.1016/j.lwt.2017.09.019

Ayyash M, Al-Nabulsi AA, Olaimat AN, Al-Holy M, Holley RA (2023) Enhancing the rheological, gelation, and functional properties of camel milk yogurt with pea extract. ACS Food Science & Technology 3(11): 1988–2000. https://doi.org/10.1021/acsfoodscitech.3c00366

Balakrishnan G, Agrawal R (2014) Antioxidant activity and fatty acid profile of fermented milk prepared by. *Pediococcus pentosaceus*. Journal of Food Science and Technology 51(12): 4138–4142. https://doi.org/10.1007/s13197-012-0891-9

Barefoot SF, Klaenhammer TR (1983) Detection and activity of lacticin B, a bacteriocin produced by *Lactobacillus acidophilus*. Applied Environmental Microbiology 45: 1808–1815. https://doi.org/10.1128/aem.45.6.1808-1815.1983

Bashir AYM (2009) Effect of gum Arabic on enzymatic coagulation of camel milk. Doctoral dissertation, Sudan University of Science & Technology.

Bekele M (2014) The Physicochemical characteristics and consumer acceptability of soft unripened cheese produced from camel milk and utilizing the rough concentrate of ginger (*Zingiber officinale*) as coagulant. International Journal of Dairy Science and Technology 1(1): 001–005. https://www.advancedscholarsjournals.org

Bersuder P, Hole M, Smith G (1998) Antioxidants from a heated histidine-glucose model system. I: Investigation of the antioxidant role of histidine and isolation of antioxidants high-performance liquid chromatography. Journal of the American Oil Chemists' Society 75(2): 181–187. https://doi.org/10.1007/s11746-998-0030-y

Bhagiel I, Musatafa EA, Tabidi MM, Ahmed MEM (2015) Comparison between the physiochemical attributes of yogurt processed from camel milk and that processed from cow milk and the effect of storage. World Journal of Pharmaceutical Sciences 4(8): 1530–1540.

Bibiana I, Joseph S, Julius A (2014) Physicochemical, microbiological and sensory evaluation of yoghurt sold in makurdi metropolis. African Journal of Food Science and Technology 5(6): 129–135. https://doi.org/10.14303/ajfst.2014.052

Bolívar MSB, Pasini F, Marzocchi S, Ravagli C, Tedeschi P (2023) Future perspective and technological innovation in cheese making using artichoke (*Cynara scolymus*) as vegetable rennet: A review. Foods12(16): 3032. https://doi.org/10.3390/foods12163032

Brandelli A, Daroit DJ, Corrêa APF (2015) Whey as a source of peptides with remarkable biological activities. Food Research International 73: 149–161. https://doi.org/10.1016/j.foodres.2015.01.016

Correia I, Nunes A, Duarte IF, Barros A, Delgadillo I (2005) Sorghum fermentation followed by spectroscopic techniques. Food Chemistry 90: 853–859. https://doi.org/10.1016/j.foodchem.2004.05.060

Doumandji A, Hellal A, Saidi N (2010) Purification de la bactériocine à partir de *Lactobacillus acidophilus* 11. Revue Microbiologie Indienne Sanitaire et Environnement 4(2): 25–47.

Eissa EA, Yagoub AEA, Babiker EE, Ahmed IAM (2011) Physicochemical, microbiological and sensory characteristics of yoghurt produced from camel milk during storage. Electronic journal of Environmental, Agricultural and Food Chemistry 10(6): 2305–2313.

Farah Z (1996) Camel milk: properties and products. StGallen: Swiss Centre for Development Cooperation in Technology and Management.

Feiden T, Valduga E, Zeni J, Steffens J (2023) Bioactive Compounds from Artichoke and Application Potential. Food Technology and Biotechnology 61(3): 312–327. https://doi.org/10.17113/ftb.61.03.23.8038

Fguiri I, Atigui M, Sboui A, Samira A, Marzougui C, Dbara M, Hammadi M, Khorchani T (2021) Camel milk-clotting using plant extracts as a substitute to commercial Rennet. Journal of Chemistry 2021: 6680246. https://doi.org/10.1155/2021/6680246

Fratianni F, Tucci M, De Palma M, Pepe R, Nazzaro F (2007) Polyphenolic composition indifferent parts of some cultivars of globe artichoke (*Cynara cardunculus* L. var. *scolymus* (L.) Fiori). Journal of Food Chemistry 2007(104): 1282–1286. https://doi.org/10.1016/j.foodchem.2007.01.044

Garcia-Gomez B, Vazquez-Oderiz L, Munoz-Ferreiro N, Romero-Rodriguez A, Vazquez M (2020) Rennet type and microbial transglutaminase in cheese: effect on sensory properties. European Food Research and Technology 246(3): 513–526. https://doi.org/10.1007/s00217-019-03418-6

Gil-Izquierdo A, Gil MI, Conesa MA, Ferreres F (2001) The effect of storage temperatures on vitamin C and phenolics content of artichoke (*Cynara scolymus* L.) heads. Innovative Food Science & Emerging Technologies Journal 2001(2): 199–202. https://doi.org/10.1016/S1466-8564(01)00018-2

Hashim IB, Khalid AH, Habib H (2009) Quality and acceptability of a set type yogurt made fromcamel milk. Journal of Dairy Science 92: 857–862. https://doi.org/10.3168/jds.2008-1408

Hwanhlem N, Buradaleng S, Wattanachant S, Benjakul S, Tani A, Maneerat S (2011) Isolation and screening of lactic acid bacteria from Thai traditional fermented fish (Plasom) and production of Plasom from selected strains. Food Control 22(3–4): 401–407. https://doi.org/10.1016/j.foodcont.2010.09.010

Inayat S, Arain MA, Khaskheli M, Malik AH (2003) Study of the effect of processing on the chemical quality of soft unripened cheese made from camel milk. Pakistan Journal of Nutrition 2: 102–105. https://doi.org/10.3923/pjn.2003.102.105

Khan H, Athar IH, Aslam M (2004) Evaluation of cheese prepared by processing camel milk. Pakistan Journal of Zoology 36(4): 323–326. https://www.yumpu.com/en/document/view/30039151/evaluation-of-cheese-prepared-by-processing-camel-zspcompk

Kilic S, Koyuncu M (2024) Effect of some plant additions and ripening on total phenol, antioxidant capacity, volatile compounds and sensory properties of kashar cheese. Journal of Food Science and Technology 61(1): 235–245. https://doi.org/10.1007/s13197-023-05874-1

Kim D-H, Dana J, Kim H, Kang I-B, Chan J-W, Song K-Y, Seo K-H (2016) Antimicrobial activity of kefir against various food pathogens and spoilage bacteria. Korean Journal of Food Science Animal Resource 36(6): 787–790. https://doi.org/10.5851/kosfa.2016.36.6.787

Kjeldahl J (1883) A new method for the determination of nitrogen in organic matter. Zeitschrift für Analytische Chemie 22: 366–382. https://doi.org/10.1007/BF01338151

Lajnaf R, Attia H, Ayadi MA (2023) Technological properties and biological activities of camel α-lactalbumin: A review. International Dairy Journal 139: 105563. https://doi.org/10.1016/j.idairyj.2022.105563

Lourens-Hattingh A, Viljoen BC (2001) Yogurt as probiotic carrier food. International Dairy Journal 11: 1–17. https://doi.org/10.1016/S0958-6946(01)00036-X

Mehaia MA (1993) Fresh soft white cheese (domiati-type) from camel milk composition, yield, and sensory evaluation. Journal of Dairy Science 76(10): 2845–2855. https://doi.org/10.3168/jds.S0022-0302(93)77623-7

Mehaia MA (2006) Manufacturing of fresh soft white cheese (Domaiti type) from dromedary milk using ultra-filtration process. Journal of Food Technology 4: 206–212.

Moslehishad M, Ehsani MR, Salami M, Mirdamadi S, Ezzatpanah H, Naslaji AN, Moosavi-Movahedi AA (2013) The comparative assessment of ACE-inhibitory and antioxidant activities of peptide fractions obtained from fermented camel and bovine milk by *Lactobacillus rhamnosus* PTCC 1637. International Dairy Journal 29(2): 82–87. https://doi.org/10.1016/j.idairyj.2012.10.015

Namaei MH, Ghannadkaf M, Ziaee M (2015) Antibacterial effect of non-industrial yogurt on *Salmonella* and *Shigella*. Modern Care Journal 12(3): 109–113.

Nicosia FD, Puglisi I, Pino A, Baglieri A, La Cava R, Caggia C, de Carvalho AF, Randazzo CL (2022) An easy and cheap kiwi-based preparation as vegetable milk coagulant: Preliminary study at the laboratory scale. Foods 11(15): 2255. https://doi.org/10.3390/foods11152255

Pacifico S, Caputo E, Piccolella S, Mandrich L (2024) Exploring new fruit- and vegetable-derived rennet for cheese making. Applied Science 14(6): 2257. https://doi.org/10.3390/app14062257

Rahman MS, Emon DD, Nupur AH, Rahman Mazumder MA, Iqbal A, Alim MA (2024) Isolation and characterization of probiotic lactic acid bacteria from local yogurt and development of inulin-based synbiotic yogurt with the isolated bacteria. Applied Food Research 4(2): 100457. https://doi.org/10.1016/j.afres.2024.100457

Saadi S, Saari N, Anwar F, Hamid AA, Ghazali HM (2015) Recent advances in food biopeptides: Production, biological functionalities and therapeutic applications. Biotechnology Advance 2015(33): 80–116. https://doi.org/10.1016/j.biotechadv.2014.12.003

Seifu E (2023) Camel milk products: innovations, limitations, and opportunities. Food Production, Processing and Nutrition 5: 15. https://doi.org/10.1186/s43014-023-00130-7

Serra A, Conte G, Corrales-Retana L, Casarosa L, Ciucci F, Mele M (2020) Nutraceutical and technological properties of buffalo and sheep cheese produced by the addition of kiwi juice as a coagulant. Foods 9(5): 637. https://doi.org/10.3390/foods9050637

Soleymanzadeh N, Mirdamadi S, Kianirad M (2016) Antioxidant activity of camel and bovine milk fermented by lactic acid bacteria isolated from traditional fermented camel milk (chal). Dairy Science Technology 96(4): 443–457. https://doi.org/10.1007/s13594-016-0278-1

Sroska Z, Cisowski W (2003) Hydrogen peroxide scavenging, antioxidant and antiradical activity of some phenolic acids. Food Chemical Toxicology 41: 8–753. https://doi.org/10.1016/S0278-6915(02)00329-0

Stahl T, Sallmann HP, Duehlmeier R, Wernery U (2006) Selected vitamins and fatty acid patterns in dromedary milk and colostrum. Journal of Camel Practise Research 13: 53–57.

Thompson JK, Collins MA, Mercer WD (1996) Characterization of a proteinaceous antimicrobial produced by *Lactobacillus helveticus* CNRZ 450. Journal Applied Bacteriology 80: 338–348. https://doi.org/10.1111/j.1365-2672.1996.tb03229.x

Virtanen T, Pihlanto A, Akkanen S, Korhonen H (2007) Development of antioxidant activity in milk whey during fermentation with lactic acid bacteria. Journal of Applied Microbiology 102: 106–115. https://doi.org/10.1111/j.1365-2672.2006.03072.x

Wu HC, Chen HM, Shiau CY (2003) Free amino acids and peptides as related to antioxidant properties in protein hydrolysates of mackerel (*Scomber austriasicus*). Food Research Internatinal 36(910): 949–957. https://doi.org/10.1016/S0963-9969(03)00104-2

Zhang Y, Wang J, Ge W, Song Y, He R, Wang Z, Zhao L (2023) Camel milk peptides alleviate hyperglycemia by regulating gut microbiota and metabolites in type 2 diabetic mice. Food Research International 173(Part 1): 113278. https://doi.org/10.1016/j.foodres.2023.113278